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SKYLINE YARDING COST ESTIMATING GUIDE

by

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Abstract

Reliable cost estimation is the key to good logging planning. Estimating costs is difficult when a variety of logging plans are being considered, new systems are introduced, or diverse conditions are encountered. An approach for estimating costs that provides insight into an assortment of logging situations is needed.

In this Note we present a breakdown of yarding cost and production elements and a straightforward procedure for determining and comparing the cost of alternative systems. Computation of production rates and costs is demonstrated in the appendix with detailed worksheets.

KEYWORDS: Skidding costs, logging operations analysis/design, skyline logging.

FOREST SERVICE - U.S. DEPARTMENT OF AGRICULTURE - PORTLA

INTRODUCTION

Reliable cost estimates have always been an important part of careful timber harvest planning. For today's stringent silvicultural prescriptions and environmental standards, the preparation of accurate estimates is essential to insure economic production. Making comprehensive cost estimates is further complicated today by several factors that tend to make traditional data obsolete. Some of these factors are rapid advances in equipment design, reductions in average log size, and spiralling inflation.

In view of these influences, the conscientious planner cannot afford to rely solely on past cost records. A methodology must be at hand to structure the cost problem and thereby provide a framework for updating cost data to appropriately reflect today's economy and logging conditions. We also need a structure that furnishes insight into cost behavior to properly evaluate adjustments to cost or production parameters.

Good logging planning, like careful designing, is only achieved by selecting the optimal arrangement after a systematic evaluation of promising alternatives. Therefore, the best logging plan is the one that meets management goals and operational requirements for the least cost. Since cost is the final criterion for judging alternative yarding systems, a reliable method of estimation that can be readily adapted to a variety of situations is imperative. Ideally, the estimating procedure should be applicable to conceptual yarding plans where no hard data exist as well as to modified practices or diverse logging conditions.

PROBLEM FORMULATION

Yarding cost per unit volume, expressed in its simplest form, is the sum of owning costs and operating costs per unit of time divided by the production rate. Since these costs are made of several elements, it is necessary to break down the cost structure to observe the interrelationship of the elements and their influence on total yarding costs. The identification of cost factors of elements gives the insight needed to adjust the yarding plan to achieve minimal costs.

Axel Brandstrom, in his early study on logging costs, observed that the most significant variable affecting yarding cost and production is log size[1] (fig. 1). For small logs where production is inherently lower, yarding cost is highly sensitive to minor changes in the production rate (fig 2).

In evaluating yarding systems, it should be recognized that yarding is only one component of the total cost of a logging system. For example, today's roading costs increase faster than yarding costs, and minimal total logging costs may only be achieved by yarding longer distances. The importance of examining the total costs of each logging system is shown in the worksheets in the appendix that include costs of roading, felling, loading, and hauling. These additional costs should be considered in a comprehensive logging plan even though their analysis is beyond the scope of this estimating guide.

This guide presents a method of formulating yarding costs for a skyline system. It does not generate the numbers needed for cost estimation. Rather, this guide functions as the necessary first step in making accurate predictions by providing the foundation for cost development. It

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[1] Brandstrom, Axel J. F. 1933. Analysis of logging costs and operating methods in the Douglas fir region. 117 p., illus. West Coast Lumberman's Assoc.

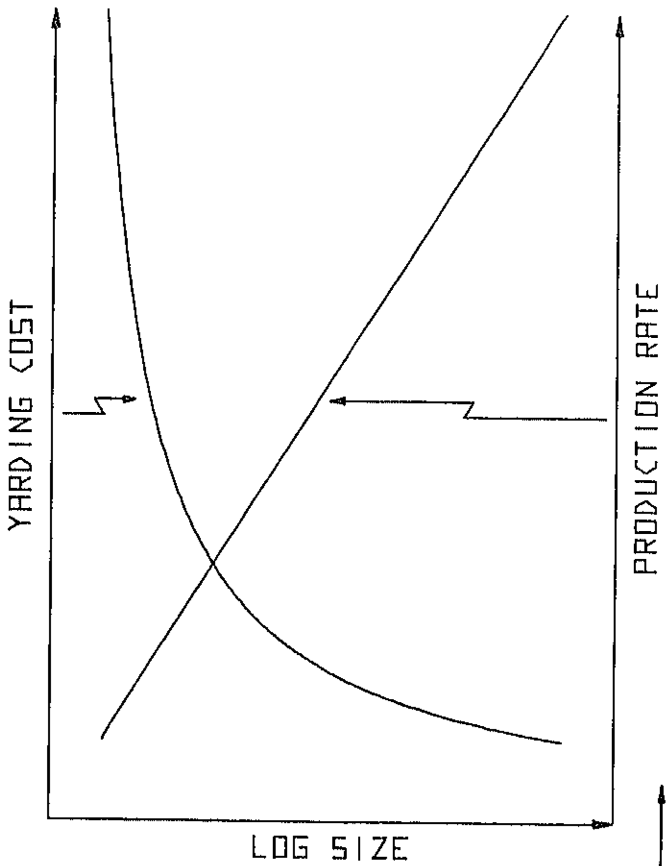

Figure 1.--Yarding cost and production rate versus log size.

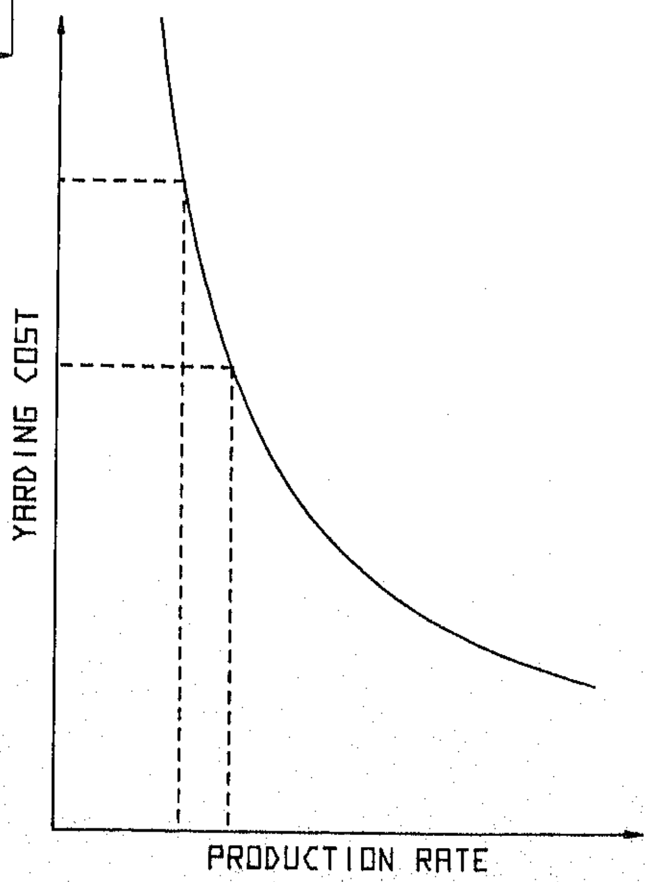

Figure 2.--Sensitivity analysis--yarding cost versus small log production rate.

serves to illuminate the yarding cost structure and to pinpoint sensitive areas where accurate data are required. The next logical step in cost estimation should be the acquisition of the following necessary data.

MACHINE RATE

"Machine rate" is a term commonly used in cost estimation to denote the total owning and operating costs per unit of time for any given equipment. Once the machine rate is established for a given yarder operation, it can generally be used with different production rates for a variety of yarding cost predictions. The machine rate must be recalculated to reflect any significant change in owning or operating costs.

A breakdown of the machine rate is shown in figure 3.

OWNERSHIP COSTS

Equipment Depreciation

For cost estimating purposes, it is generally preferable to use simple straight-line depreciation. This maintains a constant depreciation

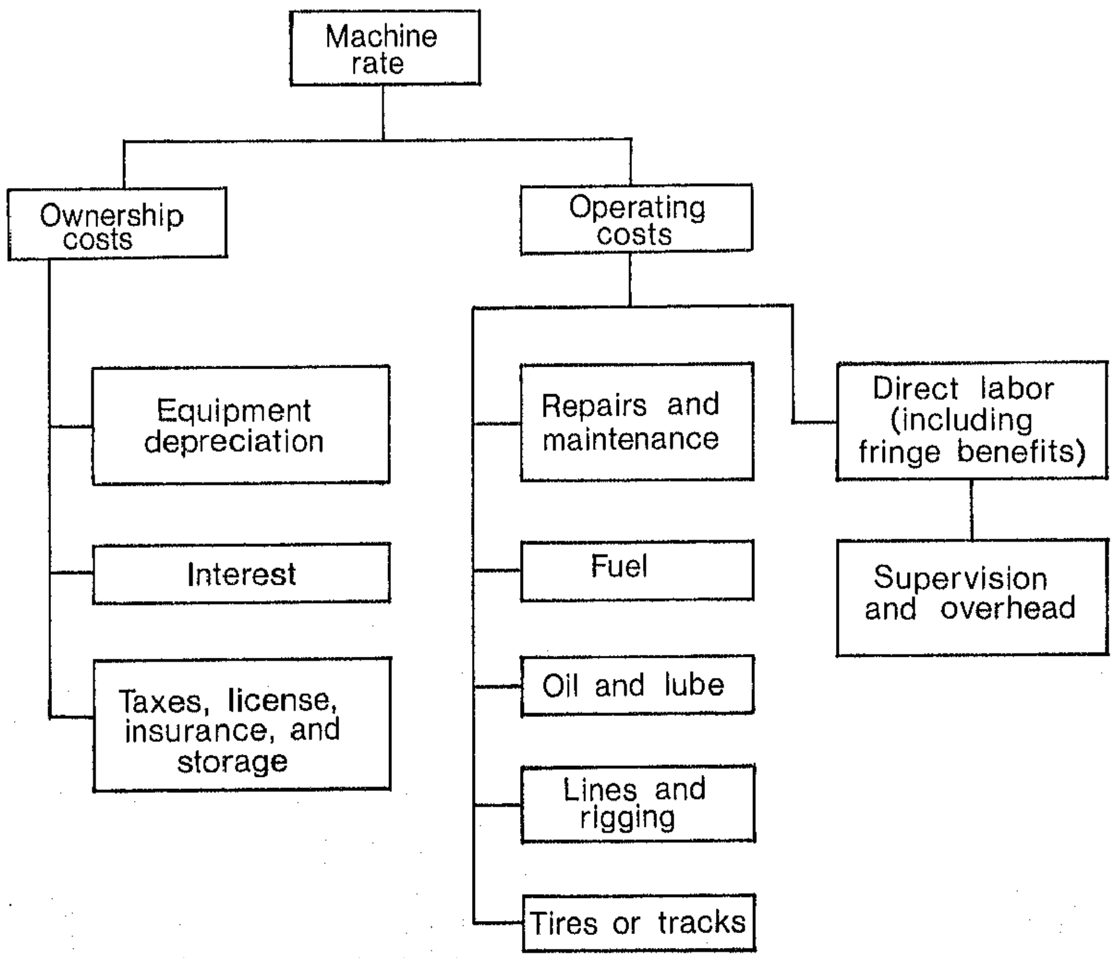

Figure 3.--Machine rate cost elements.

charge over the estimated economic life of the equipment. Residual (salvage) value is the estimated worth of the equipment at the end of the depreciation period. It may range from a high of 20 percent or more of initial cost to as low as the equipment's scrap value.

Interest

Interest may be computed as a uniform expense for the depreciation period of the equipment by applying the interest rate to the average annual investment. In today's economy, interest expense has become a very significant part of the cost of equipment ownership.

Taxes, License, Insurance, and Storage

Taken as a group, taxes, license, insurance, and storage costs can be estimated as a uniform expense based on a percentage of the average annual investment. This item may vary from 2 to 20 percent or more, depending on the type of equipment, location, etc.

OPERATING COSTS

Repairs and Maintenance

Although repairs and maintenance are related to equipment usage, the cost may be estimated as a percentage of equipment depreciation for convenience. Repairs and maintenance cost should account for repair parts and any outside labor. Crew costs related to repairs during operation are covered under delay time.

Fuel

An estimate of fuel consumption may be derived from rated engine horsepower and estimated load factor. The fuel consumption curves (fig. 4) for diesel engines are based on rated horsepower operating at average load factors ranging from 20 to 70 percent. The load factor is the percentage of full rated horsepower used during normal operation. Since cable yarders are not heavily loaded except during inhaul, their average factor usually runs under 50 percent.

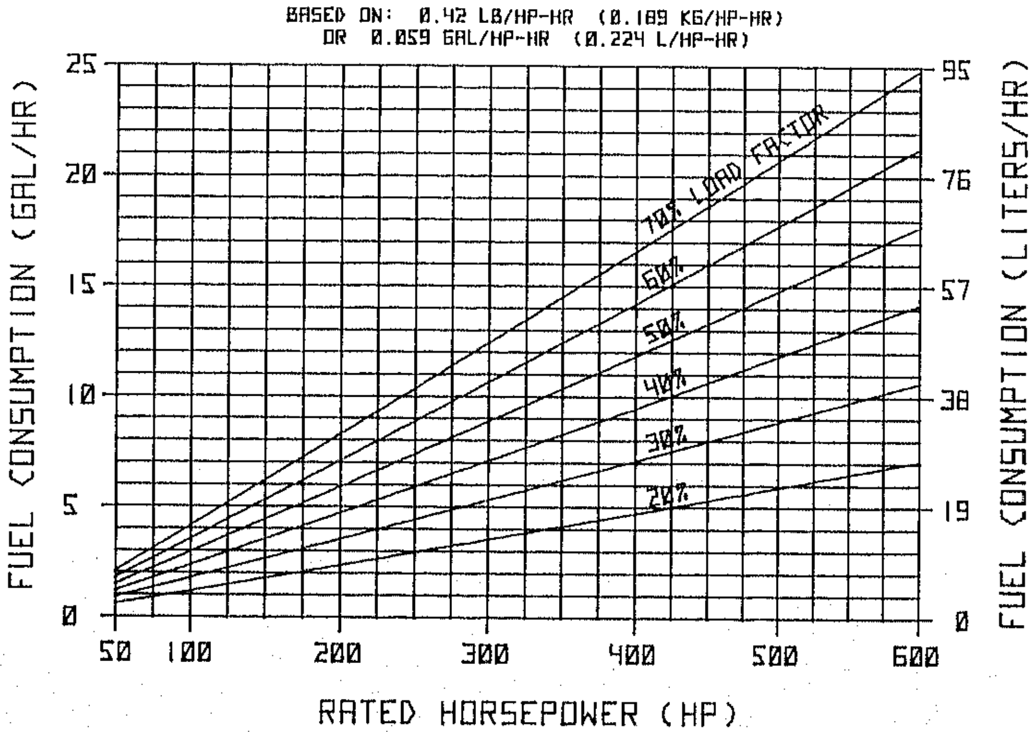

Figure 4.--Diesel engine fuel consumption chart.

Oil and Lubricants

A rule of thumb is that engine (crankcase) oil consumption equals about 1 percent of fuel consumed. Total oil requirements, including gear lube and hydraulic fluid, vary with the equipment design and may run to 5 percent of fuel consumption.

Lines and Rigging

The costs of operating lines and rigging may be charged as non-depreciable expenses. Line life and rigging life must be estimated to determine their costs on a unit-time basis. Often the life is expressed in volume of timber yarded rather than units of time. Line or rigging life must then be calculated by dividing the volume by the estimated average production rate. These assumed lives will in part determine whether the items are actually depreciated or not. For estimating costs, lines and rigging are generally considered expendable items rather than capital equipment if their estimated life is less than 2 years.

Tires or Tracks

The cost of tires or tracks is sometimes excluded from equipment value prior to depreciation. If the tire or track life is short enough to permit noncapitalization, the replacement cost may be treated as an operating expense. The useful life of tires or tracks must be estimated to arrive at the hourly cost.

Direct Labor

The full cost of direct labor includes the base wage plus fringe benefits and applicable travel pay. Fringe benefits cover such items as Workman's Compensation insurance, Social Security, unemployment insurance, sick leave, vacation, and paid holidays. Fringe benefits can be expressed as a percentage of the base wage rate.

Supervision and Overhead

Numerous indirect costs related to the operation add to the machine rate. Supervision and overhead are usually expressed as a percentage of the direct labor cost.

MACHINE RATE ESTIMATION

The worksheet shown in the appendix is furnished to facilitate the determination of machine rate. Costs may be computed on any unit-time basis, but the form is tailored to hourly costs for widest application.

YARDING PRODUCTION

Yarding production rate is the volume of timber brought to the landing per unit of time. Within a framework of scheduled operating time, the rate of production is dependent on the relative amounts of productive time and nonproductive time. These can be separated into smaller time elements, as shown in figure 5.

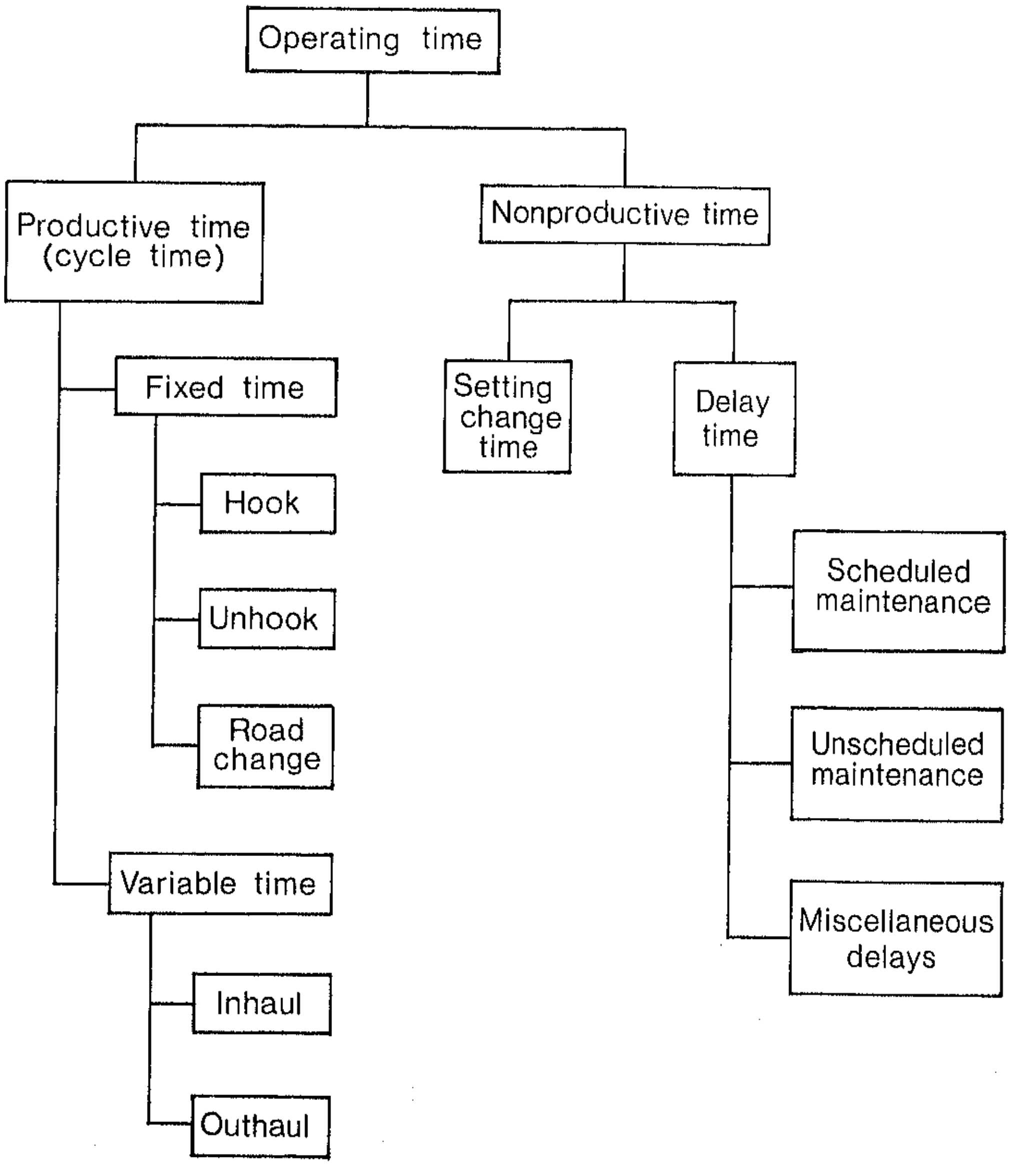

Figure 5.--Operating time elements.

PRODUCTIVE TIME (CYCLE TIME)

For convenience in estimating, the individual productive time elements are considered together as cycle time or turns per hour (turns per hour = 60/cycle time). Hook and unhook times may vary with size of pieces, pieces per turn, slope, ground or landing conditions, etc. Although their values may vary on a per turn basis, average values for settings will not change appreciably. Hook and unhook times are thus assumed to be fixed values, independent of yarding distance. The inhaul and outhaul elements are functions of yarding distance. Their relation to yarding distance may depend on numerous variables, such as carriage speed, slope, load size, etc.

Road change time may be prorated into the estimated cycle time. Road change refers to moving either the yarder or tailhold on fan-shaped settings. It should not be confused with a setting change. Road changes can frequently be accomplished with little interruption of yarding cycles. Although the time spent often cannot be identified as a discrete element, road change may represent a substantial proportion of cycle time on low volume settings.

The first step in making an estimate of cycle time is to determine the fixed time portion (fig. 6). On a per setting basis, this will normally be a constant value for most yarding systems. Generally, fixed time is also reasonably uniform among similar systems. An exception than can substantially reduce fixed time is the use of preset chokers.

The second step is to estimate turns per hour at a given average yarding distance. Average yarding distance is equal to the total distance yarded divided by the total number of turns. For rectangular and fan-shaped settings, the average yarding distance is one-half and two-thirds of the external yarding distance, respectively. The average yarding distance will vary with the size and shape of the setting and the yarding method.

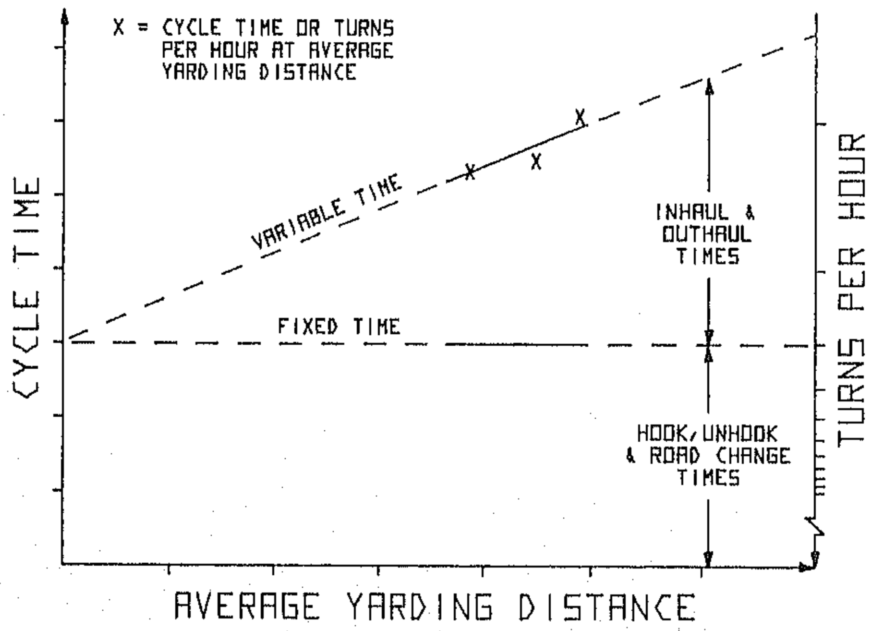

Figure 6.--Cycle time versus average yarding distance.

For cost estimation, there is no need to measure incremental elements of cycle time except to initially establish the value of fixed time. Also, yarding distance and cycle time are not required for every turn. Only the average values for the setting are needed for figuring costs.

The variable-time portion is directly related to yarding distance. One of the simplest ways of graphically representing this relationship is to plot the estimated or observed number of turns per hour at the known average yarding distance. Turns per hour can be figured by dividing the recorded number of turns for the setting by total yarding time for the setting. A single point is sufficient to initially establish the variable-time line. It must intersect the fixed-time value at zero average yarding distance. As more or better data become available, more points can be plotted and the line better fitted to the points for a closer approximation to the time-distance relation. Individual turns represent a wide range of yarding distances. Plotted points, representing average yarding distance, tend, however, to fall into a relatively narrow band where the variable-time line may be treated as linear. Cost estimation is concerned only with this band of values, indicated by the solid line portions in figure 6. A similar approach is to draw the linear variable-time line to correspond to an average value of inhaul plus outhaul in feet per minute. The variable-time line is drawn with this slope (feet per minute) starting at the intersection of the fixed-time line and zero average yarding distance; the steeper the slope, the slower the line speed of the yarder. The straight line relation depicted in figure 6 is typical of a skyline system.

Another way of determining this time-distance relationship is to plot the average cycle time versus average yarding distance for two, or preferably more, settings. When carefully plotted from reliable data, the intersection of the variable-time line with zero average yarding distance yields the predicted fixed time.

Minor operational delays--such as hangups, resetting or untangling chokers, dropping a log, etc.--can be considered normal components of cycle time. Since these delays are usually difficult to isolate and quantify as nonproductive time, they should be integrated into the value of cycle time.

Slope may influence cycle time under certain conditions, but its effect is difficult to predict. Where reliable slope correction data are available, they can be used to modify estimates of cycle time. The impact of uphill or downhill yarding and cutting treatment on the estimated cycle time should also be assessed.

NONPRODUCTIVE TIME

Setting Change Time

Moving both yarder and tailhold to a new setting is defined as a setting change. For example, setting changes are required between all parallel yarding corridors. For a well-planned cutting unit, setting change time can be estimated beforehand. Low-yield settings will increase the frequency of setting changes and result in higher production costs. Setting change time can be minimized by prerigging tailholds and anchors.

Delay Time

Delay time is difficult to estimate; type and condition of equipment, yarding conditions, and record of past down time must be taken into account. Delay time can be most easily expressed as a percentage of cycle time or turns per hour.

Scheduled maintenance covers regular servicing and replacement of parts, lines, and rigging. This maintenance is preferably performed during lengthy delays or outside the normal shift so that its impact is small.

Unscheduled maintenance refers to repair of equipment, line, or rigging after breakdown and is therefore unpredictable.

Miscellaneous delays are scheduling or other major operational delays including time lost because of inclement weather.

CALCULATION OF COST PER UNIT VOLUME

The worksheets in the appendix may be used to calculate the cost per unit volume of yarding a given unit. Average log volume for the stand can be obtained from timber cruise data. Judgment should be exercised in estimating a realistic volume per piece as bucked, since actual piece lengths may vary from the cruise data log length.

Similarly, cruise data can supply a figure for percent defect in the entire stand, but the percent defect will normally be lower in the pieces yarded.

The estimate for average number of logs per turn should consider any influencing factors, such as piece size, deflection, size and suitability of the landing, or distribution of pieces within the unit.

Move-in and move-out costs should cover all charges relating to preparation of equipment and transportation to and from the cutting unit.

Roading, felling, loading, and hauling costs are beyond the scope of this estimating procedure but should be included in the total logging system cost of any logging plan.

APPENDIX

Example Worksheets and Blank Copies for Reader's Use

Equipment Ownership Cost

Delivered equipment cost	\$ 250,000
Less line and rigging cost	− \$ 12,000
Less tire or track replacement cost	− \$ N/A
Less residual (salvage) value	− \$ 50,000
Depreciable value	\$ 188,000

Equipment depreciation: $\frac{\text{(Depreciable value)}}{\text{(Depreciation period)}} = \frac{(\$\ 188{,}000\ )}{(\ 7\ \text{yr})}$ \$ 26,857 /yr

Average annual investment: $\frac{\text{(Depreciable value)} \times \text{(Depreciation period + 1)}}{2 \times \text{(Depreciation period)}} + \text{(Residual value)}$

$$= \frac{(\$\ 188{,}000\ ) \times (\ 8\ )}{2 \times (\ 7\ )} + (\$\ 50{,}000\ ) = \$\ 157{,}429\ /\text{yr}$$

Interest expense: (Annual interest rate) x (Average annual investment) = (10 %) x (\$ 157,429 /yr) + \$ 15,743 /yr

Taxes, license, insurance & storage: 9 % of Average annual investment = (9 %) x (\$ 157,429 /yr) + \$ 14,169 /yr

Annual ownership cost: \$ 56,769 /yr

Annual utilization: (200 days worked/yr) x (8 hours worked/day) = 1600 hr/yr

Ownership cost: $\frac{\text{(Annual ownership cost)}}{\text{(Annual utilization)}} = \frac{(\$\ 56{,}769\ /\text{yr})}{(\ 1600\ \text{hr/yr})}$ \$ 35.48 /yr

Equipment Operating Cost

Repairs and maintenance: $\frac{50\text{ \% of Equipment depreciation}}{\text{Annual utilization}} = \frac{(50\%) \times (\$26{,}857\text{ /yr})}{(1600\text{ hr/yr})}$ — \$ 8.39 /hr

Fuel: (7 gal/hr) x (\$ .45 /gal) — + \$ 3.15 /hr

Oil & lubricants: (4 % of fuel consumption) x (unit cost) = (4 %) x (7 gal/hr) x (\$ 1.50 /gal) — + \$ .42 /hr

Lines: $\frac{\text{(Cost)}}{\text{(Estimated life)}} = \frac{(\$\ 9500)}{(800\text{ hr})}$ — + \$ 11.88 /hr

Rigging: $\frac{\text{(Cost)}}{\text{(Estimated life)}} = \frac{(\$\ 2500)}{(3200\text{ hr})}$ — + \$ .78 /hr

Tires or tracks: $\frac{\text{(Replacement cost)}}{\text{(Estimated life)}} = \frac{(\$\ \_\_\_\_)}{(\_\_\_\_\text{ hr})}$ — + \$ N/A /hr

Crew position: Yarder Engr. | Rig. Slinger | Chaser | Chokersetter | Chokersetter | ____

Base wage: \$ 9.60 /hr + \$ 9.30 /hr + \$ 8.20 /hr + \$ 7.70 /hr + \$ 7.70 /hr + \$ ____ /hr

Total crew wage: \$ 42.50 /hr

Direct labor cost: $\text{(Total crew wage)} \times \left[\frac{(100 + \text{\% fringe benefits})}{100} + \frac{\text{(travel time/day)}}{\text{(operating time/day)}}\right]$

$= (\$\ 42.50\text{ /hr}) \times \left[\frac{(100 + 30\ \%)}{100} + \frac{(.5\text{ hr/day})}{(8\text{ hr/day})}\right]$ — + \$ 57.91 /hr

Supervision and overhead: 15 % of direct labor cost = (15 %) x (\$ 57.91 /hr) — + \$ 8.69 /hr

Operating cost: — \$ 91.22 /hr

Machine rate: (Ownership cost) + (Operating cost) = (\$ 35.48 /hr) + (\$ 91.22 /hr) — \$ 126.70 /hr

Cruise Data

Area of unit: A = 35 acres

Yield per acre : V = 40 MbF / acre

Gross unit volume: V_T = (V) x (A) = (40 MbF / acre) x (35 acres) = 1400 MbF

Average volume per log as cruised = .21 MbF

Average volume per piece as bucked: v = .25 MbF

Percent defect in stand as cruised = 10 %

Percent defect in pieces as yarded: D = 6 %

Engineering Data

Number of settings in cutting unit: N = 8

Average yarding distance = 480 ft.

Estimates

Average number of pieces per turn: n = 3.2

Average volume per turn: v_t = (v) x (n) = (.25 MbF) x (3.2) = .8 MbF

Average turns per hour: C = 12.5

Delay as a percentage of turns per hour: d = 15 %

Adjusted turns per hour: c = (C) x $\frac{(100-d)}{100}$ = (12.5) x $\frac{(100 - 15\ \%)}{100}$ = 10.6

Time per setting change: t_s = .67 hours

Total setting change time: T_s = (t_s) x (N - 1) = (.67 hr) x (7) = 4.7 hours

Move-in and move-out cost, M: $ 2000

Calculations

Number of turns: $\dfrac{(\text{Gross volume, } V_T)}{(\text{Volume per turn, } v_t)} = \dfrac{(\text{1400 MbF})}{(\text{.8 MbF})} = \underline{1750}$

Operating time: $\dfrac{(\text{Number of turns})}{(\text{Adjusted turns per hour, } c)}$ + Total setting change time

$= \dfrac{(1750)}{(10.6)} + \underline{4.7}\text{ hr} = \underline{169.8}\text{ hours}$

Yarding cost: (Machine rate) x (Operating time) = (\$ 126.70 /hr) x (169.8 hr) = \$ 21,513.66

Add move-in and move-out cost, M: + \$ 2000

Total yarding cost: \$ 23,513.66

Yarding cost per gross unit volume: $\dfrac{(\text{Yarding cost})}{(\text{Gross volume, } V_T)} = \dfrac{(\$\ 23{,}513.66)}{(\text{1400 MbF})} =$ \$ 16.80 / MbF

Net volume: $(\text{Gross volume, } V_T) \times \dfrac{(100 - \%\text{ defect, D})}{100} = (\text{1400 MbF}) \times \dfrac{(100 - 6\ \%)}{100} =$ 1316 MbF

Yarding cost per net unit volume: $\dfrac{(\text{Yarding cost})}{(\text{Net volume})} = \dfrac{(\$\ 23{,}513.66)}{(\text{1316 MbF})} =$ \$ 17.87 / MbF

For total logging system cost, add:

Roading cost per net unit volume = + \$_____/_____

Felling cost per net unit volume = + \$_____/_____

Loading cost per net unit volume = + \$_____/_____

Hauling cost per net unit volume = + \$_____/_____

Total logging cost per net unit volume = \$_____/_____

Equipment Ownership Cost

Delivered equipment cost	\$______
Less line and rigging cost	– \$______
Less tire or track replacement cost	– \$______
Less residual (salvage) value	– \$______
Depreciable value	\$______

Equipment depreciation: $\dfrac{\text{(Depreciable value)}}{\text{(Depreciation period)}} = \dfrac{(\$\_\_\_\_\_\_)}{(\_\_\_\_\text{yr})}$ \$______/yr

Average annual investment: $\dfrac{\text{(Depreciable value) x (Depreciation period + 1)}}{\text{2 x (Depreciation period)}}$ + (Residual value)

$= \dfrac{(\$\_\_\_\_\_\_) \text{ x } (\_\_\_\_)}{2 \text{ x } (\_\_\_\_)} + (\$\_\_\_\_\_\_) = \$\_\_\_\_\_\_/\text{yr}$

Interest expense: (Annual interest rate) x (Average annual investment) = (____%) x (\$______/yr) + \$______/yr

Taxes, license, insurance & storage: ____% of Average annual investment = (____%) x (\$______/yr) + \$______/yr

Annual ownership cost: \$______/yr

Annual utilization: (______days worked/yr) x (____hours worked/day) = ______hr/yr

Ownership cost: $\dfrac{\text{(Annual ownership cost)}}{\text{(Annual utilization)}} = \dfrac{(\$\_\_\_\_\_\_/\text{yr})}{(\_\_\_\_\_\_\text{hr/yr})}$ \$______/yr

Equipment Operating Cost

Repairs and maintenance: $\dfrac{\text{\% of Equipment depreciation}}{\text{Annual utilization}} = \dfrac{(\_\_\_\%) \times (\$\_\_\_\_\_\_\_\_/\text{yr})}{(\_\_\_\_\_\_\text{hr/yr})}$ $________/hr

Fuel: (______gal/hr) x ($______/gal) + $________/hr

Oil & lubricants: (___% of fuel consumption) x (unit cost) = (___%) x (____gal/hr) x ($______/gal) + $________/hr

Lines: $\dfrac{\text{(Cost)}}{\text{(Estimated life)}} = \dfrac{(\$\_\_\_\_\_\_\_\_)}{(\_\_\_\_\_\_\text{hr})}$ + $________/hr

Rigging: $\dfrac{\text{(Cost)}}{\text{(Estimated life)}} = \dfrac{(\$\_\_\_\_\_\_\_\_)}{(\_\_\_\_\_\_\text{hr})}$ + $________/hr

Tires or tracks: $\dfrac{\text{(Replacement cost)}}{\text{(Estimated life)}} = \dfrac{(\$\_\_\_\_\_\_\_\_)}{(\_\_\_\_\_\_\text{hr})}$ + $________/hr

Crew position: ________ ________ ________ ________ ________ ________

Base wage: $_____/hr + $_____/hr + $_____/hr + $_____/hr + $_____/hr + $_____/hr

Total crew wage: $______/hr

Direct labor cost: (Total crew wage) x $\left[\dfrac{(100 + \text{\% fringe benefits})}{100} + \dfrac{\text{(travel time/day)}}{\text{(operating time/day)}}\right]$

$= (\$\_\_\_\_\_\_/\text{hr}) \times \left[\dfrac{(100 + \_\_\_\%)}{100} + \dfrac{(\_\_\_\_\_\_\text{hr/day})}{(\_\_\_\_\_\_\text{hr/day})}\right]$ + $________/hr

Supervision and overhead: ____% of direct labor cost = (____%) x ($________/hr) + $________/hr

Operating cost: $________/hr

Machine rate: (Ownership cost) + (Operating cost) = ($______/hr) + ($______/hr) $________/hr

_____

_: V = ________/______

V_T = (V) x (A) = (______/_____) x (________) = ________

.og as cruised = ________ Average volume per piece as bucked: v = ________

:and as cruised = _____% Percent defect in pieces as yarded: D = _____%

n cutting unit: N = ______

Average yarding distance = ________

Estimates

Average number of pieces per turn: n = ______

Average volume per turn: v_t = (v) x (n) = (_______) x (_______) = ________

Average turns per hour: C = ________

Delay as a percentage of turns per hour: d = _____%

Adjusted turns per hour: c = (C) x $\frac{(100 - d)}{100}$ = (______) x $\frac{(100 - \quad \%)}{100}$ = ________

Time per setting change: t_s = ________ hours

Total setting change time: T_s = (t_s) x (N - 1) = (______ hr) x (______) = ________ hours

Move-in and move-out cost, M: $________

Calculations

Number of turns: $\frac{\text{(Gross volume, } V_T\text{)}}{\text{(Volume per turn, } v_t\text{)}} = \frac{(\qquad\qquad)}{(\qquad\qquad)} =$ ________

Operating time: $\frac{\text{(Number of turns)}}{\text{(Adjusted turns per hour, c)}}$ + Total setting change time

$= \frac{(\qquad)}{(\qquad)} +$ ______ hr = ________ hours

Yarding cost: (Machine rate) x (Operating time) = ($ ______ /hr) x (______ hr) = $ ________

Add move-in and move-out cost, M: + $ ________

Total yarding cost: $ ________

Yarding cost per gross unit volume: $\frac{\text{(Ysrding cost)}}{\text{(Gross volume, } V_T\text{)}} = \frac{(\$\qquad\qquad)}{(\qquad\qquad)} =$ $ ______ / ______

Net volume: (Gross volume, V_T) x $\frac{\text{(100 − \% defect, D)}}{100} =$ (______) x $\frac{(100 - \quad\%)}{100} =$ ________

Yarding cost per net unit volume: $\frac{\text{(Yarding cost)}}{\text{(Net volume)}} = \frac{(\$\qquad\qquad)}{(\qquad\qquad)} =$ $ ______ / ______

For total logging system cost, add:

Roading cost per net unit volume = + $ ______ / ______

Felling cost per net unit volume = + $ ______ / ______

Loading cost per net unit volume = + $ ______ / ______

Hauling cost per net unit volume = + $ ______ / ______

Total logging cost per net unit volume = $ ______ / ______

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